CHAPTER 4: CALIFORNIA'S OCEAN ECOSYSTEM

CALIFORNIA'S OCEAN ECOSYSTEM

Habitats within California's ocean ecosystem contain some of the most biologically diverse natural communities in the world. The abundance of species and habitats located offshore California can be attributed to the inter-relationship of the identified resource zones located both onshore and offshore. Onshore, an extensive system of inland waterways provide habitat for various marine species, as well as freshwater and nutrient flows. Offshore, several major oceanic factors, such as the California and Davidson Currents and a hydrological phenomenon known as upwelling, contribute essential nutrients to nearshore and deep ocean waters. These factors create at least three offshore regions between Mexico and Oregon which exhibit notably different biogeographical characteristics due to currents influencing temperature, nutrients, and distribution of the organisms and their offspring. It is beyond the scope of this analysis to fully identify the many factors affecting the diversity of biological resources off the California coast. However, the analysis does describe the major interactions between different ocean resource zones, how these interactions affect diversity, and the fact that modifications in one zone may strongly influence biological processes in other zones located miles away.

OCEAN RESOURCE ZONES

For descriptive purposes, the habitats which make up California's ocean ecosystem have been grouped into four geographic zones (see Figure 4-1):

- **inland watershed zone,** including all watersheds within the State that ultimately drain from their headwaters into the Pacific Ocean;
- **enclosed waters zone,** including the waters and associated terrestrial habitats of bays, estuaries, coastal wetlands and lagoons;
- **nearshore ocean zone,** including nearshore open coastal waters out to the boundary between the Continental Shelf and Continental Slope (depths range from 100 to 300 meters depending on the location); and
- **offshore ocean zone,** extending from the boundary between the Continental Slope and Continental Shelf to the edge of the exclusive economic zone (200 miles offshore).

The following sections provide examples of the habitat types, flora and fauna, and current issues that relate to each ocean resource zone. This summary is not intended to be a comprehensive accounting of the natural characteristics or issues that may arise within these zones, but rather to generally describe the inter-relationships between these zones to emphasize the need for management approaches which are responsive to the needs of the overall ocean ecosystem. Such an approach, termed ecosystem management, recognizes and responds to these inter-relationships for the benefit of all resources and species within California's ocean ecosystem, including species listed under federal or state law as threatened or endangered (see Appendix G). More detailed analyses of current issues affecting California's ocean ecosystem are provided in Chapter 5.

THE INLAND WATERSHED ZONE

California's extensive inland watershed zone consists of the watersheds surrounding the approximately 7,800 miles of rivers, creeks and drainages, traversing diverse climates, geography, and topography as they meander towards the Pacific Ocean. These watersheds play a critical role in providing freshwater flows which support anadromous fish and dependent habitats, such as coastal wetlands and nearshore

coastal waters. In addition, these watersheds provide habitat and cover, as well as transporting sediment from inland sources to the sea, providing a critical source of sand for beaches along the entire California coast.

Habitat Types

The health and productivity within California's inland watershed zone depends on the appropriate distribution of sediments, adequate vegetation along waterways, and sufficient flows of freshwater. Coniferous forests, common along northern streams and in the upper reaches of most watersheds, function to retain topsoil and prevent sediment loading in rivers. When sediment loads increase, stream channels and associated wetlands may lose their effectiveness for flood control and as wildlife habitat. Riverside forests and riparian woodlands provide nutrients, shade, and channel stability, permitting river waters to support spawning and the survival of young fish, such as salmon. Freshwater wetlands, also common to the inland watershed zone and often associated with rivers, are important for controlling and reducing the effects of peak flood flows, breaking down pollutants from contaminated waters, providing fish and wildlife habitat, and settling sediments before they reach coastal or urbanized areas. Adequate stream flow and water quality are required for anadromous fish to reach their spawning grounds, successfully spawn, rear to emigration size, and safely reach the ocean.

Flora and Fauna

Numerous fish species spend most of their lives in the ocean, but are seasonally dependent upon rivers and streams for reproduction. Known as anadromous fish, these species include the Coho and Chinook salmon, steelhead trout, American shad, striped bass and white sturgeon. Anadromous fish require rivers and associated tributaries for migratory routes, as well as for spawning and nursery grounds. Although these species historically used rivers and streams along the entire coast of California, the strongest remaining populations of anadromous fish typically occur in the rivers near and north of the San Francisco Bay. Some anadromous fish, such as the striped bass and white sturgeon, mainly spawn in the Sacramento-San Joaquin Delta.

Striped bass (an introduced species), as well as many native anadromous fish, have shown significant population declines in the last decade. For instance, the winter-run Chinook salmon in the Sacramento River has decreased in recent years from a high run of 117,808 fish in 1969 to a run of 200 adults in 1994 and 1,300 adults in 1995 (Schafer (a), pers. comm.). At least sixteen marine anadromous fish species depend on the inland watershed zone for survival at some point during their life cycles (Moyle, pers. comm.).

Current Issues

Land reclamation activities, including agriculture and urbanization, have resulted in a significant loss of the state’s historic distribution of freshwater and riparian wetlands. In addition, dam construction, river channelization and water diversions have altered the natural flow of many rivers which, in combination with increased sediment loads from such activities as logging and cattle grazing, has diminished recreational and environmental values. Pollution also has become a problem with nearly 75% of the pollutants entering marine waters originating from land-based activities (Weber 1993). These pollutants ultimately find their way to coastal wetlands or nearshore ocean waters. Overall, habitat alteration, including modifications in water management regimes, increased pollutant loads, and impacts of introduced plant and animal species, has adversely affected many fish and wildlife populations dependent upon the waters of the inland watershed zone.

Looking Forward

A variety of efforts have been initiated to reverse this trend. The California Department of Fish and Game, California Department of Water Resources, and U.S. Bureau of Reclamation, have ongoing habitat restoration and fishery protection programs within the Central Valley. These projects include stream bank protection, stabilization, and re-vegetation, as well as installation of structures to provide cover, renovating scour holding and rearing pools, new and improved fish screening devices, increased stream flows, and removal of barriers to upstream migration. Two major restoration activities are currently underway in the Central Valley to help recover and maintain such anadromous fish as Chinook salmon, steelhead, striped bass and sturgeon. The congressionally-mandated Central Valley Project Improvement Act has the goal of doubling these fish populations by using some of the aforementioned measures. The CalFed Bay-Delta Program is developing a comprehensive plan for actions to restore the biological carrying capacity of the San Francisco Bay/Sacramento-San Joaquin Delta estuary as well as the many of the key streams in the watershed.

A variety of other planning efforts are in progress, such as the development of a water quality protection program for the Monterey Bay National Marine Sanctuary, which is developing strategies for watershed management reaching far into the Salinas Valley. The Coastal Conservancy is completing a number of watershed management plans on many waterways flowing to the ocean including the Klamath, Eel, Garcia, Navarro, Russian, Petaluma, Napa, Salinas, Santa Clara, Santa Ynez, Ventura, Santa Margarita and Otay Rivers and for a number of major creeks. When completed, these plans will specify restoration and enhancement projects intended to improve riparian and wetland habitats, which play such an important role in the health of California's ocean ecosystem. The California Department of Parks and Recreation has been active in watershed and habitat restoration activities on State Park System lands, including stream and river stabilization and restoration, exotic species removal, prescribed fire use, road removals, and land form restoration. The Governor's 1997-98 Budget proposes a $3.8 million Watershed Initiative to assist the Department of Fish and Game, the State Water Resources Control Board, the Department of Conservation, and the Department of Forestry and Fire Protection in efforts to reduce water quality and habitat impacts in key watersheds throughout the State of California.

THE ENCLOSED WATERS ZONE

The enclosed waters zone is ecologically, economically, and recreationally important to California, as bays, estuaries, coastal wetlands and lagoons are the places where land meets the sea. Freshwater originating from as far away as the Sierra Nevada mixes with saltwater from the Pacific Ocean and, in the process, creates some of the State's most unique and sensitive habitats. This zone differs from the inland watershed or ocean zones because of the mixing of fresh and salt water and the substantial influence of tidal forces on the habitat. While the enclosed waters zone supports an abundant and diverse assemblage of plants and animals, it is largely dependent upon nutrient inputs from the inland watershed, nearshore ocean, and to a lesser extent, offshore ocean zones for maintenance of these organisms.

Habitat Types

Emergent coastal wetlands, mudflats, and seagrass meadows are the major habitat types present within the intertidal portions of the enclosed waters zone. These three habitats, although distinct in many ways, are strongly dependent upon one another. Transitions among these habitats are often gradual, with the same nutrients, plants and animals sometimes found in more than one habitat. For example, young fish and invertebrate species migrate between emergent wetlands and submergent seagrass meadows as tidal fluctuations submerge and expose different areas of an estuary.

Emergent coastal wetlands usually occur in intertidal marine, brackish, and freshwater areas of the enclosed waters zone. Vegetation produced in wetlands supports an extensive food chain, largely based on the consumption of decaying plant material by organisms known as detritivores. Although vegetation

production in wetlands may be high, the diversity of vegetation species is low due to difficult conditions created by salinity and fluctuating water levels. Ecologically connected to coastal wetlands, upland areas within the inland watershed zone are a refuge for many creatures from rising tides and raging storms.

Mudflats, composed of soft, fine sediments, are another common habitat in the enclosed waters zone, occurring in intertidal areas. Mudflats form in areas where impacts from ocean wave activity is low and water movement is minimal. These conditions create a gentle slope that is much flatter than that observed for sandy beaches. These gentle slopes, coupled with fine sediment particles, result in long water retention, in turn allowing organic material to accumulate and serve as an abundant food source for the creatures residing in mudflats.

Submerged seagrass meadows are another prominent habitat in the enclosed waters zone and often occur in the shallow subtidal areas. Dense seagrass beds, in conjunction with emergent wetlands, perform many important functions, such as providing fish and wildlife habitat, reducing coastal erosion, and filtering pollutants from the water column before they can flow into the Pacific Ocean. Soft bottom channels and submerged seagrass beds often provide a transition between the enclosed waters and nearshore ocean zones. These habitats are less conspicuous than others in this zone because they are frequently covered by water and, therefore, usually not seen by the casual observer. Tidal scour and freshwater flushing create highly changing sediment and salinity conditions, and are the driving force in the formation of seagrass beds and soft bottom channels. Currents in the channels can reach velocities of up to several knots, creating soft bottom areas where organisms must be highly adapted for survival. Tidal conditions in submerged seagrass beds are diminished, allowing sediment to settle and seagrasses and other organisms to flourish. Although conditions in the subtidal habitat can be severe, anadromous fish and other organisms have adapted to and use the habitat as migratory channels and feeding grounds.

Flora and Fauna

The high productivity of plants and algae in the enclosed waters zone attracts large numbers of animals. For instance, habitat provided by the stems and roots of emergent wetland and submerged seagrass vegetation provides spawning, nursery, and feeding grounds for important fishery species, such as the striped bass, California halibut, white sea bass, herring, and various salmonids. Taller wetland plants, such as the cordgrasses and bulrushes, provide cover and nesting sites for the endangered light-footed clapper rail, while shorter vegetation provides habitat for the endangered Belding's savannah sparrow. Other prominent coastal birds, such as the snowy egret, great blue heron, and endangered least tern, are common to wetland and seagrass habitats, while eelgrass (the dominant seagrass species in the enclosed waters zone) is the primary food source for the black brant, a migratory goose. This region also provides important habitat for other species including amphibians, reptiles, and mammals, some of which have been listed as either threatened or endangered (see Appendix G).

The apparently barren appearance of mudflats is deceiving. Organic material carried into mudflats via tidal action is decomposed by microscopic bacteria which play a vital role in recycling food for other organisms. Bacteria are very abundant in mudflats, with populations of hundreds of million per gram of sediment. Nutrients made available by bacteria support algae, including diatoms and blue-green algae which can form mats up to one centimeter thick. Sediments provide habitat for large populations of commercially valuable invertebrate species, such as clams and oysters, as well as non-harvested species such as other mollusks, crustaceans, and worms. Staghorn sculpin, starry flounder, leopard shark, and California skate are common fish in mudflats. Mudflats also provide foraging areas for many coastal birds, including the long-billed curlew, marbled godwit, snowy plover, and gulls.

Current Issues

Evidence suggests that many bays, estuaries, coastal wetlands and lagoons have been substantially altered or eliminated in California. Historically, ninety percent of emergent wetland habitats and more than half the mudflats in the enclosed waters zone have disappeared, while substantial levels of seagrass meadows

have been lost. Most of this loss is the result of physical displacement from coastal developments, or the result of modifications to other resource zones which eliminate the supply of fresh and salt water to these areas. (Dennis and Marcus 1984).

For instance, hydrological changes in a watershed drainage may adversely reduce or increase the supply of water or nutrients to distant coastal wetlands and seagrass meadows. These changes can also increase sediment loads and runoff, causing adverse effects to watershed ecosystems that include smothering flora and fauna, increased streambank erosion, and increased turbidity. Water quality degradation from polluted runoff generated within inland watersheds and from point sources can affect resources such as shellfish beds and nursery habitats for various species of fish. Events that sometimes occur offshore, such as oil spills that reach bay, estuarine, and wetland habitats, can have devastating affects on resources within the enclosed waters zone. Other activities that impact this zone include dredging and filling activity to maintain harbor channels and entrances, as well as increasing instances of non-native species being transported into California ports from ships discharging foreign ballast water. Many introduced plant and animal species are reproducing in large numbers and competing with native species.

In addition, sea level rise is a phenomenon that may significantly affect the enclosed waters zone. For example, research conducted in the San Francisco Bay Area indicates that, over the last 120 years, the sea level at Golden Gate Bridge has risen an average of about 2 millimeters per year or about 9.5 inches total (Conomos, et al 1985). There are predictions that global warming may cause the sea level to rise another 2 to 3 feet in the next several decades. If this occurs, there will be dramatic changes in the shoreline and dynamics of the enclosed waters of the San Francisco Bay/Sacramento-San Joaquin Delta system, the largest estuary in California.

Looking Forward

Although some wetland losses continue, the conversion of major wetlands and other resources within the enclosed waters zone has been largely abated, and properly designed and monitored mitigation projects are being conducted to increase such habitats. Habitat restoration and mitigation projects, either planned or ongoing, are being pursued for many coastal wetlands throughout the State, consistent with the Governor’s 1993 wetlands conservation policy which calls for no overall net loss of wetlands, and for achieving a long-term gain in the quantity, quality, and permanence of wetland acreage and values. For example, the Sonoma Baylands, Elkhorn Slough, Cargill Baylands, Ballona Wetlands, and Batiquitos Wetlands projects are intended to result in substantial increases in the quantity and quality of habitat values in those areas.

Regional planning efforts will be important in restoring and/or enhancing resources within the enclosed coastal waters zone. Regional wetlands planning is essential to the success of implementing the Governors wetlands conservation policy. The plan implementing that policy calls specifically for three geographically-based regional strategies, including the San Francisco Bay Area and Southern California.

In the San Francisco Bay Area there are many concurrent wetlands planning and protection efforts underway. These efforts were called for both in the Governors policy and the San Francisco Estuary Project's Comprehensive Conservation and Management Plan. Many of these efforts are based on cooperative outreach with landowners and other stakeholders. A program designed to develop regional wetlands goals is currently being undertaken by the Regional Wetlands Ecosystem Goals Project (a coalition of government, the private sector, and academia). This group is working to provide a common basis for identifying important wetlands resources, setting future restoration and enhancement goals, and working together to improve the decision making process.

In Southern California, the Governor's plan calls for the development of a joint venture project to set wetlands restoration and enhancement goals. This process has not yet been formally instituted; however, a coastal wetlands inventory has recently been initiated by the State Coastal Conservancy, California Coastal Commission, and U.S. Fish and Wildlife Service. Additional data may be gathered to address the

important coastal watershed wetlands resources. There are a number of coastal wetland restoration projects either underway or being proposed for Southern California area.

Lastly, the complicated issue of introduced or exotic species to the State's bays, estuaries, coastal wetlands, lagoons and adjacent lands must be addressed. These species have been invading California's ocean ecosystem, particularly within and around San Francisco Bay, resulting in substantial environmental and economic damage, including the destruction of wooden pier structures and the crowding out of many native species of ecological importance. The California Department of Parks and Recreation has been active in removing exotic species, as well as in dune stabilization and re-vegetation, on California parklands. The California Department of Water Resources also spends considerable resources on studying and removing harmful exotic species. New measures may be necessary at the State, federal, and international levels to develop ballast water discharge procedures that will reduce the introduction of waterborne exotic species into California waters.

THE NEARSHORE OCEAN ZONE

The nearshore ocean zone extends from such onshore areas as sandy beaches, boulder fields and rocky outcroppings, including associated kelp beds, sandy and muddy bottoms, to the boundary between the continental shelf and continental slope (depths range from 100 to 300 meters, depending on the location). Waters of this zone are rich in nutrients primarily from upwelling currents and partially from freshwater inflows, supporting an abundance of habitats and organisms which also offer many economic and recreational opportunities.

Productive oceanographic factors, such as major ocean currents, stimulate biological productivity and diversity in both nearshore and offshore ocean waters. The California Current is a cold water current that originates north of California and moves southward along the coast, whereas the Davidson Current is a periodic, nearshore current that flows in a northerly direction, carrying warm waters from semitropical seas to Southern California. Another factor is upwelling, the movement of deep ocean waters into shallower, nearshore areas. Upwelling provides essential nutrients needed to support vast populations of microscopic organisms collectively known as plankton. Plankton are a vital component of numerous food webs supporting important fish, mammal and bird populations.

Interactions between offshore currents influence temperature, nutrients, and distribution of organisms and their offspring and create three distinct marine biogeographical regions (or bioregions) along the coast of California. The southern region, extending from the Mexican border to Point Conception near the City of Santa Barbara (known as the Southern California Bight), is composed of warmer waters and primarily supports temperate and warm water fish and invertebrate species. Point Conception is a transition zone where warmer Southern California waters mix with colder waters from the north. The second region is located offshore the Central and Northern California coast, extending from Point Conception to Cape Mendocino where another transition zone occurs. A third region, extending from Cape Mendocino beyond the California/Oregon border (sometimes known as the Oregonian Province), contains colder waters and organisms adapted to such conditions. (Cailliet and Greene, pers. comm.). These distinctions are important, because they play a major role in explaining offshore conditions and differences in species distribution along the coast.

Habitat Types

Wave action exerts a strong influence on habitat distribution within the nearshore ocean zone. Fine, sandy beaches often occur in areas where wave action is light, while beaches with more coarse sand are found where wave activity is stronger. Sandy beaches are dynamic habitats in which sediments are constantly shifted down the coast and between deeper and shallower waters. Waterways in the inland watershed zone play an important role in this process because they transport sediments that ultimately provide sand for the State's beaches. Boulder fields occur in areas of greater wave activity, and rocky outcroppings

occur where wave action is the greatest. The pounding surf within boulder fields and rocky shores often creates small habitats known as tidepools, which support creatures uniquely adapted for survival under such extreme physical conditions as temperature variation, salinity, and wave action. Although shoreline habitats may appear distinct from those offshore, they are dependent upon each other, with the exchange of nutrients and organisms among them being common.

Kelp forests, shale, and sandy and muddy bottoms are the dominant habitat types occurring just offshore. Kelp forests are common in areas with rocky substrates and may extend for miles along the coast, forming habitats that, in some ways, function similarly to terrestrial forests. Species may be found at different depths within kelp forests, which grow in water depths up to 100 feet. Some organisms prefer the anchor-like holdfasts near bottom sediments, others prefer the stem-like stipes in the mid-water column, and still others mostly inhabit upper canopy areas near the ocean's surface. Shale, also known as hard bottom, occurs in the nearshore ocean zone as a substrate for burrowing organisms.

Sandy and muddy bottoms are common along the entire coast of California. Sandy bottoms are located intermittently along the coast, while muddy bottoms are most common at the mouths of rivers and estuaries, where sediment loads of silt and clay settle out as the water moves further offshore.

Flora and Fauna

California's nearshore ocean zone is rich in biodiversity and commercially important species. Giant kelp, common to many coastal regions, is the largest and fastest growing algae in the ocean. While kelp forests provide refuge and forage areas for many sea creatures, they are also harvested regularly for use in manufactured products, such as cosmetics and ice cream. Commercial and recreational fishing have a long history in California's nearshore ocean zone. Some species with current commercial value include the sea urchin, squid, abalone, spiny lobster, California halibut, Pacific mackerel, rockfish, and several species of crab. Commercial importance can vary over time; for example, in just over 20 years, the red sea urchin has risen from virtual obscurity to become California's largest grossing single-species fishery.

Many vertebrates, including fish, birds and mammals, also are common in the nearshore ocean zone. The sandy beaches of Southern California serve as the major spawning grounds for grunion, which wriggle onto beaches during certain full moons to mate and lay eggs. Rockfish, white seabass, lingcod and various perch species are common to kelp forests, while white croaker, halibut and other flatfishes often inhabit muddy and sandy bottoms. Shorebirds, such as sandpipers, godwits and curlews frequent sandy and muddy shores, where they feed on tiny invertebrates buried beneath the sand. Other bird species, including many gulls, the endangered California least tern, the threatened brown pelican, and the snowy plower, nest and feed within this zone. Many of these species can be particularly sensitive to disturbance.

Several mammal species depend on nearshore ocean habitats for forage and breeding grounds. Harbor seals, sea lions and elephant seals are among the pinnipeds commonly seen along the coast of California. San Miguel Island, located in the Santa Barbara Channel Islands National Marine Sanctuary, is estimated to support the largest concentration of pinnipeds in the world. The California sea otter, a threatened species, occurs locally along the central coast of California, usually in association with kelp forests and sea urchin colonies. Once numbering less than 100, the sea otter population in California has risen to approximately 2300 individuals. Whales and dolphins swim into nearshore waters, but these species are more common in deeper, offshore waters.

Current Issues

Throughout the world, coastal areas tend to support large human populations. A problem associated with increasing populations is coastal development and increased pollution. Discharge of pollutants from point sources, such as sewage and industrial wastes, is monitored closely in California although the appropriate level of treatment continues to be controversial. Another problem of an international nature is that Mexico's discharge regulations are less strict, which has resulted in some increased pollution levels in the

waters offshore San Diego. Waters of the nearshore ocean zone also receive pollution from such sources as agriculture and urban run-off from watersheds in the inland watershed zone. In addition to increased water pollution, dredging and filling that accompany coastal construction and development have significantly affected the ecological functioning of many nearshore areas. Comprehensive monitoring programs for nonpoint sources of pollution have not yet been established.

Discharge and intake systems from coastal desalination facilities, coastal power generating stations, and waste treatment facilities (discharges only) all affect California's nearshore ocean zone. Issues arising from these operations include fish and larval entrainment from intake systems and potential adverse impacts to kelp, fish, other marine species, and humans from coastal discharges. Oil spills, both on and offshore can also cause substantial adverse impacts to resources within the nearshore ocean zone. Numerous government and private sector efforts are moving forward to reduce these impacts.

In the 1800's, many species of marine mammals which live in the nearshore ocean zone were hunted to near extinction for their fur, meat, and oil. However, enactment of the federal Marine Mammal Protection Act of 1972 now protects these creatures, and many populations have grown significantly in recent years. The population of northern elephant seals, for instance, was once reduced to less than 100 individuals by hunting and now numbers approximately 80,000 in California. California sea lions now number approximately 160,000 along the California coast, with an average annual population increase of about 8 percent (Schultze, pers. comm.). In fact, some of marine mammals are at or above historic levels and are beginning to occupy habitat not previously used. This has resulted in some inevitable conflicts with humans, which are likely to increase as marine mammal populations continue to expand. Recovery of these species is due in part to cooperative efforts of California's commercial fishers and fishery managers to dramatically reduce the take of marine mammals such as sea otters, harbor seals, and sea lions in fishing gear in recent years. However, the take of some species of whales is occurring in certain fisheries at a level that is inconsistent with the provisions of the Marine Mammal Protection Act. Therefore, particular efforts are being initiated to seek reductions in the take of these species from some drift gill net fisheries.

Some coastal fishery stocks have declined, resulting from a combination of factors such as habitat disruption, changing ocean conditions, and overfishing. Funding limitations have significantly reduced the ability of most State and federal agencies to implement necessary resource assessment and habitat restoration efforts or to fully enforce existing fishery management laws and regulations to help identify changes and, where necessary, reduce the decline of fishery stocks.

Looking Forward

A variety of efforts to identify and control sources of nonpoint pollution are underway by several departments within the Resources Agency and the California Environmental Protection Agency. However, ongoing and potentially expanded water quality maintenance and monitoring programs will be essential to ensure that water quality standards are being met. Interaction between growing populations of marine mammals and humans is an issue that must receive more attention in the future. Some species, such as elephant seals, are hauling out and breeding on mainland sites for the first time ever. In some cases these breeding grounds are moving toward popular beaches frequented by recreational users which creates potential hazards for both humans and elephant seals. Competition between marine mammals and both sport and commercial fisherman for fishing grounds is another concern which may have to be addressed in the future. While management guidelines have been formulated for most important fisheries in California, comprehensive management is conducted for only a few, such as northern anchovy, Pacific sardine, and Pacific herring.

THE OFFSHORE OCEAN ZONE

The offshore ocean zone of California begins at the boundary between the continental shelf and continental slope and extends to the edge of the exclusive economic zone (200 miles offshore). The exceptions to this

general definition are deep submarine canyons which split the shelf in some areas and bring the deep ocean environment in close proximity to shore. For example, the Monterey Submarine Canyon in Central California reaches a depth of nearly two miles and approaches within 300 feet of the beach. This diversity of depths, combined with a strong connection to the ecology of both upland habitats and deep ocean waters, creates an environment vital for supporting a diverse biological community and significant economic, recreational, and educational opportunities.

Productive oceanographic factors stimulate biological productivity and diversity in both nearshore and offshore ocean waters. These factors include the California Current, periodic Davidson Current, and the phenomena known as upwelling, which provides essential nutrients needed to support vast populations of plankton. Plankton are a vital component of numerous food webs that support important fish, mammal and bird populations. Three biogeographical regions (or bioregions) are created by these factors: 1) Mexico to Point Conception, known as the Southern California Bight; 2) Point Conception to Cape Mendocino; and 3) Cape Mendocino north into Oregon, known as the Oregonian Province. These regions are discussed in greater detail in the nearshore ocean zone description.

Habitat Types

The habitats of this zone are generally identified as an upper area where sunlight is sufficient to support primary productivity, a middle transitional area where sunlight is weak and not supportive of primary productivity, and a lower area completely beyond the influence of sunlight. Another habitat is often identified as the surface of the ocean which supports birds and other species which require both air and water to survive. Each of these habitats has a unique ecology with characteristic plants and animals (or lack thereof). In general, temperature, oxygen, atmospheric pressure, and nutrients combine to restrict many species to specific depths. On the other hand, there are many species that use more than one habitat area during their life cycle or even on a daily basis. For example, anchovies most frequently school in commercial quantities near the surface, but at certain times of year they are known to school at depths greater than 200 meters during the day and near the surface at night. Also, while bottom-dwelling animals may never leave their deep ocean realm as adults, their eggs and larva can often be found in the transitional or upper habitat areas.

Flora and Fauna

In the relatively shallow waters of the offshore ocean zone, there is an abundance of plankton. Phytoplankton directly harness the power of the sun through photosynthesis, while zooplankton feed upon the phytoplankton. Small and abundant, plankton form the base of many food chains and support such commercial fisheries as herring, mackerel and sardine. In addition to being consumed by small fish, plankton also support shrimp-like crustaceans known as krill, the major source of nutrition for the largest creatures on earth, including blue and fin whales. The offshore ocean zone also supports other important fishery stocks typically restricted to deeper waters, including tuna, swordfish, rockfish, sablefish, Pacific hake and flatfishes.

The abundant food sources in the offshore ocean zone also support other vertebrate populations, including numerous bird and marine mammal species. Several large birds, such as albatrosses, frigatebirds and various gulls, travel many miles from shore into the offshore ocean zone to feed on crustaceans and small fishes. California sea lions and northern elephant seals also travel far out to sea in search of fish and other food sources. Although blue and fin whales are now relatively uncommon in the offshore zone, other marine mammals are commonly found in California's offshore waters, including gray and humpback whales and several species of dolphins and porpoises.

Current Issues

Similar to other natural areas in California, the offshore ocean zone and its inhabitants are facing increasing pressures from human activities. Dredge disposal, oil and gas operations, shipping operations, military

exercises, seismic testing, or sound experiments in the water column can disturb or potentially harm marine life within this zone. For instance, change in the historical migratory patterns of gray whales along California's coast has been associated with shipping activity and increased noise pollution, while overfishing and nearshore habitat degradation may be adversely affecting populations of several important fishery species. Marine mammals can be adversely effected by commercial or sport fishing (competition for food supply and accidental by-catch), ingestion of plastics and other human generated wastes in the marine environment, loss of food supply, and encroachment on resting and breeding areas. Unfortunately, assessing the health of marine populations is difficult due to the costs associated with assessment and insufficient knowledge about the marine environment and its inhabitants. The data bases and vital statistics regarding many marine species are often limited or non-existent.

Looking Forward

There are indications of improving conditions in some aspects of the offshore ocean zone, and ecosystem degradation in others. The most current biological surveys indicate that blue, fin, and humpback whale populations have grown markedly in recent years. The number of gray whales migrating between Mexico and the Bering Sea along the California coast appears to represent those estimated to have existed prior to the onset of commercial whaling activities in the Pacific Ocean. Consequently, the gray whale has recently been taken off the federal endangered species list. Associated with this resurgence of marine mammal populations has been a corresponding growth in the west coast "whale-watching" industry.

Although conditions for some species are improving, a study released by the Scripps Institution of Oceanography (Scripps) indicates that warming trends in Southern California waters are resulting in substantial zooplankton kills off the west coast. These water temperature increases may be robbing surface water of valuable nutrients needed to sustain the zooplankton populations. The phenomenon, which is cited as occurring over the last 10-30 years, is having a detrimental impact on higher level marine resources, such as fishery and seabird populations, that previously existed off the coast. (Roemmich and McGowan 1995). Long term monitoring of ocean conditions and fisheries is critical for determining the health of ocean resources.

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) has completed 45 years of sampling physical, chemical, and biological resources within the California Current off Southern California. In 1994, CalCOFI published the second of two atlases which summarize the distribution and abundance of fish larvae collected on CalCOFI surveys from 1951 to 1984. CalCOFI is working with scientists from the National Oceanic and Atmospheric Administration, Scripps, California Department of Fish and Game, Mexican government, and others on a wide variety of research and monitoring efforts.

CONCLUSION

California's four resource zones are dynamic and interdependent, forming one of the biologically richest ecosystems in the world. Management of the ocean's resources must take into consideration this interdependence and recognize that impacts generated in one resource zone may ultimately affect resources in another zone.

The ocean ecosystem also contributes substantially to the economic health of the State. However, numerous human activities are exerting increasing pressures on the marine environment, which can negatively affect California's precious ocean resources and the commercially valuable industries they support. California's coast has supported human activities since early settlements were established, but environmental impacts have increased as growing human populations compete for land, port and harbor facilities, recreational areas, fishing grounds, mineral resources, and reserves for natural resource protection. Now, more than ever, it is important that California's ocean management program assess the ecological and economic impacts of activities on California's ocean ecosystem, and to determine the most

effective and efficient methods for addressing those impacts. Success in this initiative will be highly dependent on the ability of the State to focus attention on resolving major policy issues in cooperation with all levels of government, the public, and the private sector.